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TRX01

Transceiver for ISM radio applications

By G. Raedersdorf

The TRX01 from Atmel is a single-chip transceiver that has been designed for low-power, wireless applications and is optimised for use in the 433-MHz and 868-MHz ISM bands, where licence-exempt data communication is permitted.

Technical specifications:

- All transmit/receive-functionality on board
- Power supply from 2.4 to 5 V; so can operate from batteries
- Operates from 400 to 950 MHz with Digital Channel Selection on the 433-, 868- and 915-MHz bands
- Data transmission with Digital Channel Select up to 50 kbit/s
- FSK modulation, completely integrated modulator
- Data transmission without protocol up to a speed of 100 kbit/s
- Synthesiser oscillator for RX and TX
- Digital fine tuning of the carrier frequency in steps of 200 Hz
- Integrated RX/TX switch
- Short RX/TX change-over time (< 200 µs)
- Fast frequency shift (< 50 µs for a shift of 100 kHz)
- 10 dBm (10 mW) output power at 2.4 V with 8 digitally selectable levels, maximum power 25 mW in the 868-MHz band
- Sensitivity -100 dBm
- Energy saving functions: sleep-mode en wake-up mode
- Current consumption less than 60 mA while transmitting and 30 mA while receiving, this drops to 3 µA in sleep mode and 1 µA in power-down mode
- Simple configuration and control via special registers
- Digital readout of RSSI and battery voltage
- Available in a 48-pin TQFP package

This new IC (type AT86RF211) from Atmel can communicate with any microprocessor via a 3-wire bus. The device can be completely configured (output power, frequency) through this interface. Even the battery voltage and the received signal strength are measured. These parameters are available in the status register. There is also a timer, among other things, that allows for the possibility to automatically start the circuit after some period of time.

Two of these ICs make it possible to build a reliable connection over a distance of several hundreds of meters.

As can be seen in the above photograph, the IC is housed in an SMD package with many connections (48-pin TQFP package). The IC is, nonetheless, quite easy to solder using a soldering iron with a fine tip.

The most important technical details can be found in the accompanying table. A data sheet for this IC is also available from Atmel in PDF-format. It can be downloaded from:
www.atmel.com/atmel/products/prod281.htm

After perusing the documentation, you will quickly come to the conclusion that this is a very flexible chip, which is partially explained by the high level of integration.

Typical applications for these ICs are systems related to telemetry, remote control, burglar alarms, radio

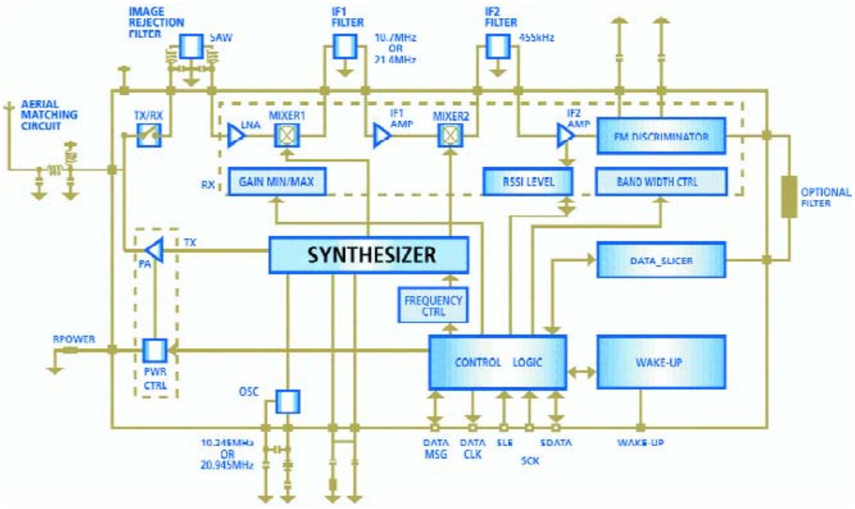

Figure 1. Block diagram of the TRX01 (source: Atmel).

modems, etc. All these application areas are grouped together under the general term ISM (Instrument, Scientific, Medical). This chip makes it possible to equip systems like these with bi-directional communications, allowing the use of communications protocols with handshaking functionality. In this way, applications such as the remote reading of instruments or handheld terminals becomes much more interesting, both from a technical and an economic perspective.

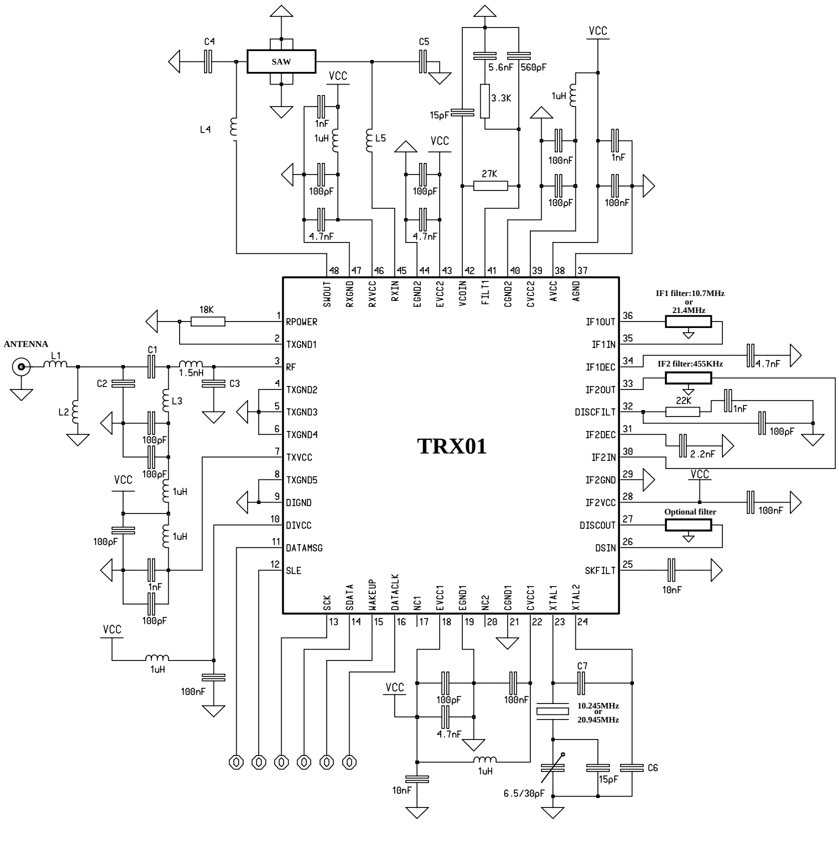

Figure 2. Schematic of a practical realisation containing a TRX211. Note the presence of a substantial number of coils.

The block diagram

A glance at the block diagram of the TRX01 (**Figure 1**) shows that we are dealing with a chip which is both complex and flexible. The various circuits encompass several electronics disciplines, such as the digitally adjustable synthesiser and related parts, control logic, RF-circuitry for, among others, the discriminator section and filters of various kinds, even SAW filters (SAW = Surface Acoustic Wave).

Synthesiser

The fast, multiple-loop synthesiser with high resolution can be tuned to two different bands: the band that occupies the region from 400 to 480 MHz and the band from 800 to 950 MHz. The individual channels within each band can be selected in software. With the exception of the PLL filter, all the synthesiser electronics are integrated on the chip. Phase detection is achieved with charge pump technology.

Power amplifier

The power amplifier is capable of delivering up to +10 dBm (10 mW) in one of the three popular bands reserved for ISM communications: 433 MHz, 868 MHz and 915 MHz (only the first two are freely available in Europe). Under certain conditions the output can even rise to above +11.5 dBm.

There as also a system to automatically regulate the output power (ALC = Automatic Level Control), so that the amplifier becomes less sensitive to fluctuations in temperature or the power supply voltage.

Receiver

The TRX01 also accommodates a complete receiver, from the RX/TX-switch to the FSK-discriminator. All stages have been designed for operation from 400 to 1000 MHz and on intermediate frequencies of 10.7 MHz, 21.4 MHz or 455kHz. The gain of the first stage is adjustable.

Selection of IF1

Because of sensitivity reasons, the designers choose for a classical super-heterodyne topology with a double IF. The input- and output impedances of the mixing stages are internally matched to the impedances of commonly available ceramic filters. For the intermediate frequency two typical values are proposed: 10.7MHz (the most frequent option) and 21.4 MHz. In the latter case the image frequency is far enough away from the carrier frequency to permit the use of a ceramic filter instead of a SAW-filter. It should be noted that 21.4-MHz ceramic filters usually have steeper slopes than 10.7-MHz ceramic filters.

FSK-modulator

The structure of the modulator is based on an oscillator. The nominal voltage of the demodulated signal is 100 mV_{pp}.

TRX01 pinouts

Pin	Name	Function
1	RPOWER	Full scale output power resistor
2	TXGND1	GND
3	RF	RF Input/Output
4	TXGND2	GND
5	TXGND3	GND
6	TXGND4	GND
7	TXVCC	VCC
8	TXGND5	GND
9	DIGND	GND
10	DIVCC	VCC
11	DATAMSG	Input/Output digital message
12	SLE	Serial interface (enable)
13	SCK	Serial interface (clock)
14	SDATA	Serial interface (data)
15	WAKEUP	Wake-up output
16	DATACLK	Data clock recovery
17	–	Test pin; do not connect
18	EVCC1	VCC
19	EGND1	GND
20	–	Test pin; do not connect
21	CGND1	GND
22	CVCC1	VCC
23	XTAL1	Crystal input
24	XTAL2	Crystal output
25	SKFILT	Threshold for data slicer
26	DSIN	Data slicer input
27	DISCOUT	Discriminator output
28	IF2VCC	VCC
29	IF2GND	GND
30	IF2IN	IF2 amplifier input
31	IF2DEC	2.2 nF to ground
32	DISCFILT	Discriminator bypass
33	IF2OUT	IF2 mixer output
34	IF1DEC	4.7 nF to ground
35	IF1IN	IF1 amplifier input
36	IF1OUT	IF1 mixer output
37	AGND	GND
38	AVCC	VCC
39	CVCC2	VCC
40	CGND2	GND
41	FILT1	Synthesizer output
42	VCOIN	Synthesizer input (VCO)
43	EVCC2	VCC
44	EGND2	GND
45	RXIN	LNA input from SAW filter
46	RXVCC	VCC
47	RXGND	GND
48	SWOUT	Switch output

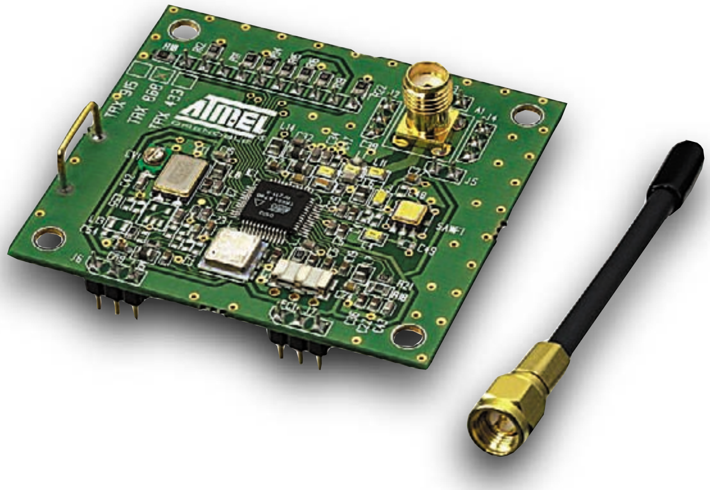

Figure 3. Daughter board with the AT86RF211 at its heart.

Crystal reference oscillator

This is an oscillator of the Colpitts type with two external capacitors. Any crystal with a parallel resonance frequency of 20.945 or 10.245 MHz is suitable.

Serial data interface

The application's microprocessor can control and monitor the TRX01 through the synchronous, bi-directional serial interface comprising 3 wires: SLE, SCK and SDATA.

Final remark: the operating frequencies of this circuit require a well thought-out PCB layout.

Practical circuit

Figure 2 shows the schematic of a practical circuit around the TRX01, the prototype of which can be seen in **Figure 3**. Note the presence of a number of RF components, such as ceramic filters and a SAW filter. Fortunately, with the exception of trimmer CV1, there is nothing to be adjusted.

Development kit

In conclusion we would like to point out to those who are interested that a development kit exists which can operate on 433, 868 or 915 MHz and consists of two autonomous systems. The kit contains an AT86RF211 daughter board, an antenna, an AVR motherboard and all the necessary pieces to create a stand-alone application: batteries, LCD, ISP functionality (In System Programming) and a remote lightmeter prototype that can be built. The kit also contains a CD-ROM with programs (in C), a user's manual and, before we forget, three samples of the AT86RD211.

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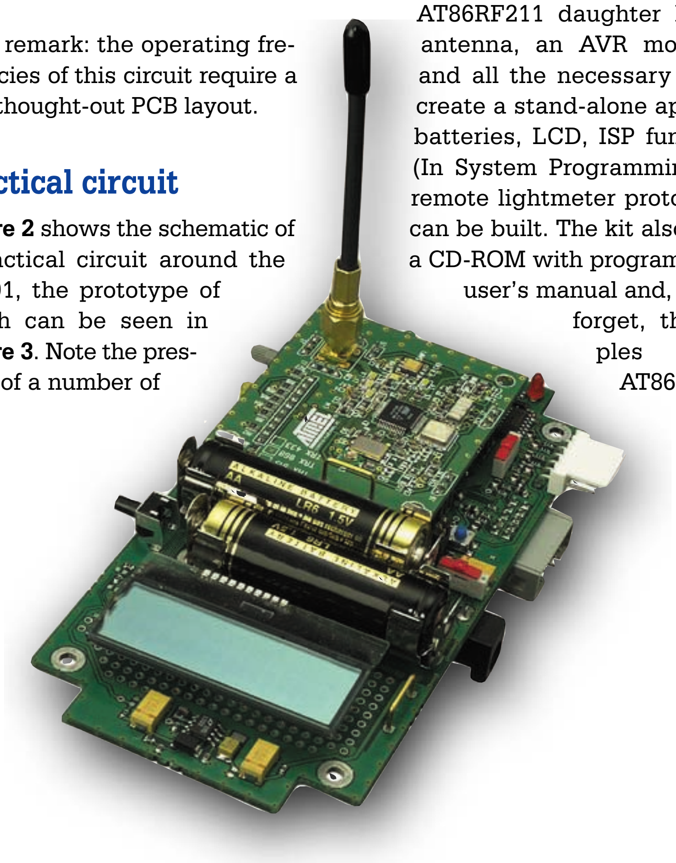

Figure 4. The complete development kit.